

A New Quark Model Approach to Hyperon Semi-Leptonic Decays*

Philip G. Ratcliffe

*Istituto di Scienze MM.FF.CC.,
II Facoltà di Scienze MM.FF.NN.,
Università di Milano sede di Como,
via Lucini 3, 22100 Como, Italy*

and

INFN – Sezione di Milano

Abstract

A new analysis of hyperon semi-leptonic decay data is presented, based on simple and general arguments for an SU(3)-breaking structure of the couplings involved. The results obtained are compatible with those of earlier investigations and highlight the uncertainties inherent in extraction of the V_{us} Cabibbo-Kobayashi-Maskawa matrix element from such data, and the need for complete analyses. For F and D , the results can be summarised by the ratio: $F/D = 0.57 \pm 0.01$; while as far as the value of V_{us} is concerned, the only conclusion to be drawn is that, insofar as SU(3) breaking is still not totally under control, the value obtained is *compatible* but not *competitive* with that obtained from kaon semi-leptonic decays.

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1 Introduction

Hyperon semi-leptonic decays (HSD) represent the only presently available source for obtaining the two axial-coupling parameters F and D separately (the sum being known rather precisely from neutron beta decay alone). In addition, these data are used for extracting a value of the strangeness-changing Cabibbo-Kobayashi-Maskawa (CKM) [1] matrix element, V_{us} . The first two of the above parameters are vital to the analysis of data on the longitudinally polarised deep-inelastic scattering (DIS) structure functions, $g_1^{p,n}(x)$, as they provide the overall normalisation for certain flavour non-singlet combinations of the different quark-parton helicity-dependent distributions. As the precision of such measurements improves, a reliable and accurate evaluation of F and D (or, more to the point, of the combination orthogonal to the sum) becomes ever-more necessary.

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The third parameter mentioned above, V_{us} , is also obtainable from the so-called $K_{\ell 3}$ decays [2]. The most recent Particle Data Group (PDG) publication [3] quotes the two values:

$$V_{us}^{K_{\ell 3}} = 0.2196 \pm 0.0023 \text{ [2]}, \quad (1)$$

$$V_{us}^{\text{HSD}} = 0.222 \pm 0.003. \quad (2)$$

From these, the PDG obtains the following world average [3]:

$$V_{us}^{\text{ave}} = 0.2205 \pm 0.0018. \quad (3)$$

Note the smallness of the error ascribed to the HSD measurement and the non-negligible weight with which it therefore contributes to the world average. Note also that the data used in eq. (2) come only from the WA2 experiment [4] and the inclusion of later data [5] would clearly alter this number slightly. Moreover, a different approach to SU(3) breaking in HSD [6] gives slightly higher value than that quoted. I shall return to these points more in detail in section 4.

The description of HSD in terms of just the three parameters discussed above relies, of course, on the validity of SU(3) flavour symmetry in hadron dynamics. Now, while isospin breaking is relatively small (of the order of less than a percent) and the QED radiative corrections are known and may be incorporated into the analysis where necessary, symmetry breaking is of the order of ten percent or more in the hypercharge direction. Inevitably then, in order to extract F and D to a precision of order, say, one percent, an accurate description of such breaking is required (or, at the very least, a parametrisation reliable at the one-percent level). In the light of the quoted PDG error on V_{us} , this need becomes particularly pressing.

In this talk, after briefly outlining the relation to proton-spin experiments, I shall discuss the standard SU(3) parametrisation and fit results, together with the simple so-called center-of-mass recoil corrections as an attempt to account for the major part of the SU(3) breaking. I shall then move on to describe a new attempt by Xiangdong Ji and myself [14] at parametrising the violations of SU(3) and conclude the talk with a few general observations: an experimental shopping list and a brief discussion of the implications for the F and D parameters and the CKM matrix elements.

2 Motivation

2.1 The need for F and D

Modulo PQCD corrections (which I shall always suppress but should be understood as implicitly present) and possible higher-twist contributions (which I shall assume negligible), the nucleon-spin sum rules can be expressed in the following form:

$$\Gamma_1^p = \int_0^1 g_1^p(x) dx = \frac{1}{2} \left[\frac{4}{9} \Delta u + \frac{1}{9} \Delta d + \frac{1}{9} \Delta s \right], \quad (4)$$

where it is understood that the polarised quark distributions, Δq , contain both quark and antiquark contributions and the integral over the momentum fraction, x , is also understood. The analogous sum rule for the neutron is obtained, via an isospin rotation, by interchanging u and d in the above expression. The Δq appearing in this expression for a high-energy quantity are related to the nucleon matrix elements of axial-vector operators: $\bar{\psi}_q \gamma_5 \gamma^\mu \psi_q$, where the λ_i are just the relevant SU(3) flavour matrices (diagonal here). They are therefore also related, via

an SU(3) rotation, to precisely the matrix elements occurring in the beta decays of the baryon octet, *i.e.*, in HSD.

Thus, the relevant axial coupling constants may be re-expressed in terms of similar sums over polarised quark distributions: *e.g.*,

$$\begin{aligned} g_A^{n \rightarrow p} &= F + D = \Delta u - \Delta d, \\ g_A^{\Sigma^- \rightarrow n} &= F - D = \Delta d - \Delta s, \quad \text{etc.} \end{aligned} \quad (5)$$

There are only the two above linearly-independent non-singlet combinations and a third, singlet, constant is supplied by the following sum:

$$g_0 = \Delta\Sigma = \Delta u + \Delta d + \Delta s, \quad (6)$$

which, modulo PQCD corrections, clearly measures precisely the total spin carried by the quarks inside the nucleon. This last is then the new constant that is effectively measured in DIS, which then allows the separation of the various flavour contributions, *providing both F and D are known with sufficient accuracy*.

In order to appreciate the importance of the precision in F and D , let us rewrite the above expressions in order to extract the value of either the strange-quark spin, Δs , or the total quark contribution, $\Delta\Sigma$:

$$\Delta s = 3\Gamma_1^p - g_A \left(\frac{3}{2} - \frac{5/3}{1 + F/D} \right), \quad (7)$$

$$\Delta\Sigma = 9\Gamma_1^p - g_A \left(\frac{3}{2} - \frac{1}{1 + F/D} \right), \quad (8)$$

where I have taken advantage of the very high precision in the measured value of g_A (the experimental error is about 0.2%). Thus, independently of the actual results for the nucleon spin measurements one sees that (using a typical average value: $F/D \sim 0.6$)

$$\frac{d(\Delta s)}{d(F/D)} \sim -2, \quad (9)$$

while the sensitivity of $\Delta\Sigma$ is only about half this. The present nucleon-spin measurements suggest that $\Delta s \sim -0.15$, which is rather larger than was expected in a naïve quark-parton model picture, but which would be completely eliminated by a shift of a mere 0.1 (or 20%) in the value of F/D .

2.2 Extraction of V_{us}

Further motivation to improve our understanding of SU(3) breaking in this system comes from its possible use for the extraction of V_{us} , the CKM matrix element. Angular correlations in the decays are directly given by g_A/g_V while the strangeness-conserving (strangeness-changing) decay rates are proportional to $|V_{ud}|^2$ ($|V_{us}|^2$). Thus, at least in principle, an independent measurement of the two elements is possible. However, the rates are also proportional to an overall factor ($c_V g_V^2 + c_A g_A^2$), where the c_i are calculable phase-space factors [7]. Now, while the normalisation of the vector couplings is well protected by the Ademollo-Gatto theorem [8] (which states that any breaking effects are second order here), there is no such control over the axial couplings. Indeed, as we shall see from the following discussion, the breaking effects are found experimentally to be typically of the order of a few percent.

The error on V_{us} quoted by the PDG above implies a knowledge of g_A to better than 1%. In contrast, while the value of V_{us} turns out to be rather stable with respect to SU(3) breaking in the axial couplings, the values one extracts from present data with the method that best describes them unfortunately implies a violation of CKM unitarity of the order of 2%. In order to properly account for this, a specific model for the breaking is required. However, the only such calculation that might allow extraction of the couplings does not, as we shall see, describe the data at all successfully.

3 The Data

Before going on to fit results and corrections, we should briefly examine the data and, in particular, we have to deal with the long-standing problem of the discrepancies presented by the neutron beta-decay data alone. The measured decay channels are represented schematically in fig. 1.

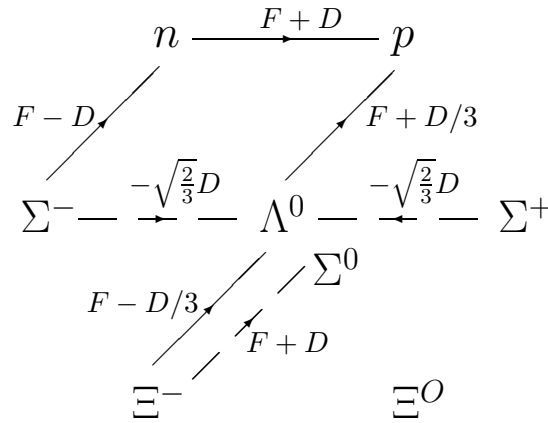


Figure 1: The measured HSD's: the solid lines represent those decays where both the rate and angular correlations are measured and the dashed lines, those for which only rates are known.

The values for the rates and angular correlations are given together with the relation to F and D in table 1. Note that a large fraction of the data are known to a precision of 5% or better and thus dealing with the problem of SU(3) breaking is clearly highly desirable at this point. One can perform various internal consistency checks, *e.g.*, between the individual decay values from rates and angular correlations. To the precision required there is no outstanding problem; however, there is a notable difficulty in the best measured sector: that of the neutron.

The beta decay of the neutron is now measured to a precision of two parts per thousand (in both the rate and the angular correlations). This highlights a discrepancy, which, while being very small in absolute terms, is rather large in terms of the number of standard deviations. Thus, in order not to cloud the examination of HSD with an artificially large overall χ^2 , I have decided to use weighted averages and then rescale the errors involved with the resulting $\sqrt{\chi^2}$. This in no way biases the HSD fits, especially since the variations of the central values are typically less than one part per thousand, and the spurious contribution to the overall χ^2 is completely eliminated. For more details, the interested reader is referred to refs. [10, 11].

Table 1: The hyperon semi-leptonic decay data, as used in this analysis [3]. The figures marked in bold type-face are those measured to a precision of better than 5%.

Decay	Rate (10^6 s^{-1})		Angular correlations g_A/g_V	g_A/g_V	$ \Delta S $
	$\ell = e$	$\ell = \mu$			
$n \rightarrow p \ell \bar{\nu}$	1.1274 ± 0.0025 ^a		1.2599 ± 0.0025 ^b	$F + D$	0
$\Lambda^0 \rightarrow p \ell \bar{\nu}$	3.161 ± 0.058	0.60 ± 0.13	0.718 ± 0.015	$F + D/3$	1
$\Sigma^- \rightarrow n \ell \bar{\nu}$	6.88 ± 0.23	3.04 ± 0.27	-0.340 ± 0.017	$F - D$	1
$\Sigma^- \rightarrow \Lambda^0 \ell \bar{\nu}$	0.387 ± 0.018			$-\sqrt{\frac{2}{3}} D$ ^c	0
$\Sigma^+ \rightarrow \Lambda^0 \ell \nu$	0.250 ± 0.063			$-\sqrt{\frac{2}{3}} D$ ^c	0
$\Xi^- \rightarrow \Lambda^0 \ell \bar{\nu}$	3.35 ± 0.37 ^d	2.1 ± 2.1 ^e	0.25 ± 0.05	$F - D/3$	1
$\Xi^- \rightarrow \Sigma^0 \ell \bar{\nu}$	0.53 ± 0.10			$F + D$	1

^aRate in 10^{-3} s^{-1} .

^bTaken from ref. [9], using the PDG value of 1.2601 ± 0.0025 makes a negligible difference.

^c $g_V = 0$, absolute expression for g_A given.

^dError scale factor of 2 included, following the PDG practice for discrepant data.

^eNot used in fits.

4 Fitting the Data

4.1 Naïve SU(3) fits

The simplest possible fit assumes SU(3) symmetry and uses three free parameters: F , D and V_{ud} (constraining V_{us} by CKM unitarity). The results of such a fit, in which no external value of V_{ud} is input, is shown in table 2, where different data subsets are also compared. Let me draw your

Table 2: An SU(3)-symmetric fit to the data.

Data	Parameters			χ^2/DoF	F/D
	V_{ud}	F	D		
Rates	0.9749 ± 0.0004	0.469 ± 0.008	0.797 ± 0.008	3.8	0.589
Ang. Corr.	$-$ ^a	0.460 ± 0.008	0.800 ± 0.008	0.8	0.576
$\Delta S = 0$	0.9795 ± 0.0020	0.528 ± 0.017	0.732 ± 0.017	$-$ ^b	0.721
$ \Delta S = 1$	0.9742 ± 0.0006	0.448 ± 0.009	0.791 ± 0.017	0.8	0.567
All	0.9750 ± 0.0004	0.465 ± 0.006	0.799 ± 0.006	3.0	0.582
All + V_{ud} ^c	0.9751 ± 0.0002	0.465 ± 0.006	0.799 ± 0.006	2.7	0.583

^aUndetermined in this fit.

^bZero degrees of freedom.

^c V_{ud} taken from nuclear ft and $K_{\ell 3}$ analysis.

attention to the perfectly acceptable χ^2 returned by the subset of angular correlation data only. This means, in particular, that *the study of the angular correlation data alone is of absolutely no relevance to the problem of SU(3) breaking*, a fact that is overlooked in many papers, even those purporting to find surprisingly large effects.

Since the main purpose here is the study of SU(3) breaking on F and D , it is then convenient to use the external knowledge of V_{ud} supplied by the $K_{\ell 3}$ and also the ft values in the so-called super-allowed 0^+-0^+ nuclear beta transitions. The results of such a series of fits are presented

in table 3. The main point to be stressed is that very little changes and that the overall χ^2

Table 3: An SU(3)-symmetric fit to the modified data including the external V_{ud} from nuclear ft and $K_{\ell 3}$ analysis (see text for details).

Data	Parameters			χ^2/DoF	F/D
	V_{ud}	F	D		
Rates	0.9749 ± 0.0003	0.469 ± 0.008	0.796 ± 0.009	3.2	0.589
Ang. Corr.	0.9752 ± 0.0007	0.460 ± 0.008	0.799 ± 0.009	0.8	0.576
$\Delta S = 0$	0.9753 ± 0.0007	0.529 ± 0.017	0.735 ± 0.017	0.5	0.719
$ \Delta S = 1$	0.9747 ± 0.0005	0.452 ± 0.009	0.799 ± 0.015	0.8	0.566
All	0.9749 ± 0.0003	0.465 ± 0.006	0.798 ± 0.006	2.3	0.582

improves, since the values of V_{ud} almost coincide. Note also that the value of F/D is very stable indeed.

Before moving on to the breaking fits, I should make a brief comment on the situation regarding V_{us} . If one now attempts to extract V_{us} independently (*i.e.*, not by invoking CKM unitarity), then one obtains

$$V_{us} = 0.223 \pm 0.002. \quad (10)$$

Such a value is marginally in violation of CKM unitarity (in excess).

I should also comment on the glaring and related discrepancy between F/D values extracted from the strangeness-changing and strangeness-conserving decays. Even taking into account the larger errors present for the two subsets, the difference is still in the order of several standard deviations. The fact that the dependence on F and D in these two subsets is rather different should warn us to be very wary that this discrepancy could be driven mainly by the very flavour violations under study.

4.2 SU(3) breaking fits

One of the most successful models for describing SU(3) breaking in this sector is based on the so-called centre-of-mass (CoM) or recoil correction [12]. The idea is simply to describe the hadron as an extended object by taking into account the smearing of the wave function due to non-zero momentum. Calculation of the relevant matrix elements then leads to correction formulæ that depend on just one parameter $\langle p^2 \rangle$, the mean three-momentum squared in the wave function, and on the masses of the baryons involved in a given decay. To calculate this parameter the authors of [12] adopted a bag-model approach, obtaining $\langle p^2 \rangle \simeq 0.43 \text{ GeV}^2$. Such an approach also provided a means to calculate the corrections arising from a possible strange-quark wave-function overlap mismatch. While it turns out that the former correction parameter actually corresponds to its minimum- χ^2 value, the latter is far too large (it is about 8% for the strangeness-changing decays) and actually worsens the fit considerably [10, 11].

The results of this simple CoM SU(3)-breaking fit (*i.e.*, without the wave-function correction) are shown in table 4. From a detailed examination of such fits, it emerges that by far the largest effects are found in the $\Sigma^\pm \rightarrow \Lambda^0$ decays, but this might have been expected as they have no g_V contribution. In any case, the overall distribution of the deviations in the final fit is perfectly normal; and so no statement can be made as to the unreliability or otherwise of any particular data point. As far as the possibility of extracting V_{us} separately is concerned, it should be noted

Table 4: An SU(3)-breaking fit to the modified data including the external, world average, value for V_{ud} .

Data	Parameters			χ^2/DoF	F/D
	V_{ud}	F	D		
$\Delta S = 0$	0.9753 ± 0.0007	0.481 ± 0.018	0.784 ± 0.018	0.5	0.613
$ \Delta S = 1$	0.9747 ± 0.0005	0.465 ± 0.009	0.825 ± 0.015	1.0	0.563
All	0.9744 ± 0.0003	0.460 ± 0.006	0.806 ± 0.006	1.0	0.571

that the fits are improved somewhat by allowing a renormalisation of the strangeness-changing decay rates. The factor required is a shift of about 2% (at the 1.5σ level) in the direction of reducing the net overshoot of CKM unitarity.

Moreover, returning to the earlier discrepancy between the $|\Delta S| = 0$ and 1 decays, we see now that it has indeed entirely disappeared. On the one hand, this comforts us that the model is working well; but, on the other, we should take this as a further strong indication of the sensitivity of V_{us} to SU(3) breaking, which I stress is not at all under control with respect to this particular aspect of the decays. On the contrary, this aspect of the decays represents the only handle on the effects of the breaking between the $|\Delta S| = 0$ and 1 decays.

5 Towards a Minimal “Model-Independent” Description

A recent approach, where generality was the key note, attempted to investigate all possible SU(3)-breaking structures [13]. The idea was that the breaking should be driven by an effective interaction with the SU(3) structure of λ_8 , the hypercharge matrix. One can show that, for the decays in question, there are four independent structures that can contribute. Unfortunately, the quality and quantity of the present data do not allow the determination of as many as four extra parameters and so the effect of each one can only be tried separately. However, since the best form could be any arbitrary combination, fitting in this fashion is of little use in attempting to understand the true breaking pattern.

In an attempt to derive a general form for the breaking pattern and, in particular, to justify the success of models based on mass-driven breaking, Xiangdong Ji and I [14] have recently tried to formulate a breaking scheme based directly on the well-known and very successful Gell-Mann–Okubo mass formulæ [15]. The idea then is to assume that the breaking is due solely to effects of the strange-quark mass and thus we separate the strong hamiltonian into its SU(3) symmetric and violating pieces: $\mathcal{H} = \mathcal{H}_0 + \mathcal{H}'$ and take \mathcal{H}' as transforming as λ_8 . Thus, as is well-known, the mass formulæ are then

$$m_B = m_0 + m_a \text{tr}(\lambda_8 B \bar{B}) + m_b \text{tr}(\lambda_8 \bar{B} B), \quad (11)$$

where m_a and m_b are two small mass parameters, which indeed allow the octet masses to be described very accurately.

If we now ascribe SU(3) breaking in HSD to the same interaction operator (\mathcal{H}') then, since the breaking is known to be small, we can adopt the following first-order perturbation-series approximation for the baryon states:

$$|B\rangle = |B\rangle_0 + \sum_{N \neq B} |N\rangle \frac{\langle N | \mathcal{H}' | B \rangle_0}{(m_0 - m_N)}, \quad (12)$$

where the (unperturbed) states, $|N\rangle$, have the same flavour (and, by hypothesis, spin) quantum numbers as $|B\rangle_0$ (since \mathcal{H}' is diagonal) and simply belong to a higher-mass representation.

Now, since the physical $|B\rangle$ of interest here are actually the lowest-lying states we can make our first serious assumption: namely, that the next-lowest-lying state $|N\rangle$ dominates the sum—it has the smallest energy denominator and is also likely to have the largest wave-function overlap with $|B\rangle_0$. Thus, the sum may be approximated by

$$|B\rangle \simeq |B\rangle_0 - \frac{1}{\Delta} \sum_{N \neq B} |N\rangle \langle N | \mathcal{H}' | B \rangle_0, \quad (13)$$

where $\Delta = m_N^{\text{lowest}} - m_0$ is a constant, equal for all baryons of the octet. Adding and subtracting the missing (first) term in the (otherwise complete) sum, one then obtains, in the so-called closure approximation

$$\begin{aligned} |B\rangle &\simeq \left(1 + \frac{\delta m}{\Delta}\right) |B\rangle_0 - \frac{1}{\Delta} \mathcal{H}' |B\rangle_0 \\ &= \left[1 + \frac{1}{\Delta} (\delta m - \mathcal{H}')\right] |B\rangle_0, \end{aligned} \quad (14)$$

where $\delta m = {}_0\langle B | \mathcal{H}' | B \rangle_0 = m - m_0$ gives just the mass shifts with respect to some common central reference point. Finally, inserting this expression into the usual expressions for the axial-vector matrix elements, one obtains

$$g_A = \left(1 + \frac{\delta m_i + \delta m_f}{\Delta}\right) {}_0\langle B_f | A_W^3 | B_i \rangle_0 - \frac{1}{\Delta} {}_0\langle B_f | \{A_W^3, \mathcal{H}'\} | B_i \rangle_0, \quad (15)$$

where i, f stand for the initial and final states and A_W^3 is just the third component of the relevant weak axial-vector operator.

The flavour matrix structure of the last, inhomogeneous, term now turns out to be rather simple, since the relevant *matrices* satisfy the following simple anticommutation relations, which would maintain the flavour structure unaltered:

$$\begin{aligned} \{\lambda_I^\pm, \lambda_8\} &= \frac{2}{\sqrt{3}} \lambda_I^\pm & (\lambda_I^\pm = \lambda_1 \pm i\lambda_2), \\ \{\lambda_V^\pm, \lambda_8\} &= -\frac{2}{\sqrt{3}} \lambda_V^\pm & (\lambda_V^\pm = \lambda_4 \pm i\lambda_5). \end{aligned} \quad (16)$$

However, the anticommutators of the *operators* concerned do not simplify in the usual way and thus this term does not reduce to the same structure as leading term, as we had hoped. What remains as an extra, undesirable, piece is a sort of diquark-diquark correlator. Therefore, if we assume, as is likely, that such an object is rather suppressed, then the corrections to g_A may simply be written in the following form:

$$g_A = g_A^0 \left(1 + \frac{\delta m_i + \delta m_f}{\Delta} \pm \epsilon\right), \quad (17)$$

where ϵ is one new free parameter describing the SU(3) breaking between strangeness-conserving (+) and strangeness-changing (−) decays (*i.e.*, the imperfect strange and non-strange quark wave-function overlap). The term in ϵ was already effectively considered above [11], but found to be small and not well determined, and thus should be neglected at this level of analysis (it is, in fact, of the same order of magnitude as the neglected higher-order terms).

Clearly, the failure to reduce the expressions to the final form cleanly (*i.e.*, without further assumptions) weakens the arguments for the simplicity of the breaking structure. One could, however, hope to salvage some of the predictiveness of this approach by taking a step back to the expression for the SU(3) broken states, eq. (12). The intermediate states in eq. (12), $|N\rangle\langle N|$, can be decomposed in terms of the possible irreducible representations contained in the product:

$$8 \otimes 8 = 1 \oplus 8 \oplus 8 \oplus 10 \oplus \overline{10} \oplus 27. \quad (18)$$

Selecting just one class (*e.g.*, the 10, which actually goes hand-in-hand with the $\overline{10}$ owing to the symmetric nature of the correction terms, *cf.*, eq. 15), one could then compare the breaking pattern so determined (obtained by fitting the data) with that obtained from any given model. Such a comparison should provide clear indications as to the validity or otherwise of the model.

6 Conclusions

6.1 Experimental shopping list

From an examination of the experimentally observed pattern of breaking and the sensitivity of the fits to the various input data, one can make the case for a more detailed experimental study of the following decays:

- $\Sigma^\pm \rightarrow \Lambda^0 \ell \nu$: not only is the breaking seen to be largest here, but this also represents the only $\Delta S = 0$ decay besides that of the neutron, whence the presence of an external, independent, value for V_{ud} would then allow a very direct examination of SU(3) breaking;
- $\Sigma^- \rightarrow n e \bar{\nu}$ and $\Lambda^0 \rightarrow p e \bar{\nu}$: these two decays can provide a better indicate as to the presence or otherwise of so-called second-class currents, which might be large here and which, it has been noted, would tend to increase the extracted value of F/D [5];
- $\Xi^- \rightarrow \Sigma^0 e \bar{\nu}$: this is the decay where the corrections might be expected to be largest of all, it also has the merit of depending on $F + D$, which is known to a very high precision, and could therefore act as a solid point of reference for breaking effects.

6.2 Theoretical considerations

In conclusion then, let me make the following observations on the HSD phenomenology that has been discussed here:

- the CoM corrections are physically motivated and provide a perfectly acceptable description of SU(3) breaking in this sector, neither needing nor indeed leaving room for any additional corrections (barring a minor global renormalisation of the strangeness-changing decay amplitudes);
- a rather more general (though admittedly not entirely model-independent) purely *mass*-driven breaking also performs acceptably well.
- it makes absolutely no sense to fit the present angular-correlation data *alone* since the breaking is completely negligible there within experimental errors—indeed, there is strong risk of susceptibility to statistical fluctuations;

- V_{us} extracted from HSD *overshoots* CKM unitarity and therefore demands a further $\sim 2\%$ renormalisation of the $|\Delta S| = 1$ decays, thus the error quoted by the PDG would appear to make no sense at all;
- the present best fit gives $F/D = 0.57 \pm 0.01$ [11] and therefore the indications for a non-zero strange-quark polarisation cannot easily be eliminated by merely appealing to SU(3)-breaking effects.

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